APPENDIX H: QUINAULT RIVER HISTORICAL AERIAL PHOTO & MAP GEOGRAPHIC TRANSFORMATION

Part 1: Aerial Photo Documentation

This section was written by Kurt Wille, Geographic Information Systems, Bureau of Reclamation, Technical Service Center, Denver, Colorado.

This data set is a compilation of historic World BIL image files, covering a portion of the Quinault River in northern Grays Harbor and southern Jefferson County, Washington from Quinault Lake to the river's confluence with the North Fork of the Quinault River. These images were created by the United States Bureau of Reclamation, Denver Technical Service Center, Remote Sensing and Geographic Information Group.

Scanned historic aerial photo sets were acquired for the study area. Image dates for the historic photos include 1939, 1952, 1958, 1962, 1973, 1982, and 1998. Each aerial photograph was plotted out and attached to this appendix for reference.
The historic scanned images were geo-referenced and rectified to horizontal control points that were derived from an 18'' pixel resolution Digital Ortho Photo (DOQ) mosaic which was developed and provided by the Quinault Indian Nation. The DOQ aerial photography was flown on July 8, 2001 and processed by the Washington State Department of Natural Resources (WDNR). It should be noted that the WDNR lists the source date as year 2000 because it was part of a large state wide project that was started in year 2000 but took two years to complete so some basins were not flown until 2001.

The input historic photo scans were geo-referenced using ESRI software. Control point values were transferred from an image point on the DOQ (example: road intersection, tree) to the same image point on the scanned photograph. Two processing techniques were used to satisfy two separate image output goals.

A first-order transformation used only points from within the floodplain. This technique was utilized to rectify the scanned photos for the purpose of delineating stream channel and floodplain features. Points from outside the floodplain were avoided to reduce error. As such, the first-order output images are not suitable for delineation of any features outside of the floodplain. The first-order output images were used in this study for mapping all channel and floodplain features compared between each photo set.

A third-order transformation using points from throughout the photo was used to rectify the entire image. The third-order output images are suitable for delineating features throughout the photo, but will not be as precise as the first-order output for areas within the floodplain. Mosaic images of the third-order images were done (ArcINFO SID files).

Root mean square (RMS) errors were documented for all of the transformations (Table 1). Relative spatial accuracy of the output images is a function of a variety of factors and varies from one image to another. One of the main factors influencing spatial accuracy is

the amount of vertical terrain variation that occurs within the bounds of each image. Images that represent earth features in more undulating terrain (mountains, canyons, etc.) will generally be less accurate. Another major factor specific to this study area is the overall lack of visible control points, especially in the upper reaches of the study area. Budget concerns did not allow vertical control to be considered in this effort. However, a vertical control component would most likely improve the overall output accuracy of transformation process.

The DOQs meet National Map Accuracy Standards; however the resulting images may not meet NMAS

Table 1. Average RMS errors by photo set and transformation technique.

First Order Transformations

Photo Set	X (meters)	Y (meters)	Range X (meters)	Range Y (meters)
1939	16.0	23.3	6.9 to 25.4	21.1 to 26.4
1952	22.5	23.1	0.3 to 84.3	0.0 to 74.5
1958	17.6	22.9	8.4 to 29.3	4.3 to 34.7
1962	12.8	10.7	9.0 to 20.7	6.4 to 14.5
1973	16.7	12.1	3.7 to 32.5	3.1 to 23.2
1982	12.3	8.7	2.5 to 37.1	1.5 to 18.4
1998	3.0	2.8	1.3 to 4.3	1.3 to 6.5

Average RMS errors by photo set and transformation technique

Third Order Transformations

Photo Set	X (meters)	Y (meters)	Range X (meters)	Range Y (meters)
1939	23.8	20.2	9.7 to 44.3	12.9 to 32.4
1958	18.6	21.6	13.4 to 31.0	10.6 to 33.9
1962	3.2	3.4	0.1 to 10.7	0.1 to 10.8
1973	16.7	13.5	5.7 to 42.6	6.3 to 36.3
1982	7.3	6.6	2.7 to 15.1	2.2 to 15.5
1998	2.1	2.0	0.3 to 3.3	1.1 to 4.3

Part 2: Methods Used in the Preparation of and Mapping on 1897, 1902, 1906, and 1913 Cadastral Surveys for Our Study Reach on the Quinault River

Introduction

As part of our assessment of part of the Quinault River, we used historical and recent aerial photographs and maps that were readily available in order to identify past and present channels.

Map Information

The 1897, 1902, 1906, and 1913 maps are cadastral surveys for the three townships and ranges in our study reach (T.23N., R.9W., T.24N., R.8W., and T.24N, R.9W.). Two surveys were done for both T.23N., R.9W. and T.24N., R.8W., and one was done for T.24N, R.9W. No survey is available for T.23N., R.8W., which is adjacent to our area.

The first survey of T.23N., R.9W. was conducted between September 9 and October 2, 1895, for the meanders of the Quinault River. The meanders were resurveyed between June 14 and June 21, 1897. The map was approved April 15, 1898, and accepted March 21, 1900. The map covers the upper end of Quinault Lake, and the river about 5900 meters upstream of the lake. The 1897 survey shows the Quinault River (spelled Quinaielt on all of the surveys) channel, sloughs (especially south of the river channel), tributaries, buildings, roads, and ownship names. It includes notes about areas that have been cleared or that are planted as orchards, but it does not show the boundaries of the modified areas. Mountainous areas were not surveyed.

The second survey of T.23N., R.9W. was conducted by G.R. Campbell between June 30 and July 2, 1902. The map was approved June 29, 1904, and accepted September 28, 1904. This map shows the Quinault River channel, section boundaries, and general areas of public, private, and mountainous (unsurveyed) land. The Quinault River channel is in the same position as it was in 1895-1897, so this map was not used in our study.

The survey for two adjacent townships and ranges, T.24N., R.8W., and T.24N, R.9W., was conducted by John R. Fenland between July 4 and July 7, 1906, for the meanders of the Quinault River in T.24N, R.9W., and between July 26 and July 27, 1906, for the meanders in T.24N., R.8W. Both maps were approved February 17, 1908, and accepted June 20, 1908. These maps show the Quinault River channel, tributaries, swamps, lakes, buildings, and some land ownship. The maps note cleared areas, but do not show boundaries of these. Mountainous areas were not surveyed.

A second map for township and range T.24N., R.8W. is dated as approved January 3, 1913. Dates when any surveying was done are not noted. The map shows the Quinault

River channel and section boundaries. The Quinault River channel is shown in the same position as it was on the 1906 map, and so this map was not used in our study.

The cadastral surveys were downloaded in jpg format from the Land Records section of the Bureau of Land Management (BLM) web site (http://www.or.blm.gov/lo/). The maps were converted to Imagine format (.img) or ESRI grids, which were used throughout the georeferencing and subsequent construction of a mosaic of the 1906 georeferenced maps.

Methods Used to Georeference and Mosaic the Maps

Each map was georeferenced to electronic versions of 1:24,000-scale topographic maps of the U.S. Geological Survey (Lake Quinault East, Finley Creek, and Bunch Lake quadrangles). The topographic maps had an original or native projection of UTM, Zone 10, NAD 27, meters, but had been reprojected into UTM, Zone 10, NAD 83, meters. The maps were georeferenced to the reprojected topographic maps using ARC. The georeferencing was done by using the corners of the 36 sections within each township and range. These points were common to both the maps and the USGS topographic quadrangles.

The following number of data points were used in georeferencing each of the surveys. For the 1897 survey of T.23N., R.9W., 22 data points were used. For the 1902 survey of T.23N., R.9W., 24 data points were used. For the 1906 survey of T.24N., R.8W., 31 points were used. For the 1913 survey of T.24N., R.8W., 33 points were used. For the 1906 survey of T.24N., R.9W., 28 points were used.

Georeferencing was done using 3rd-order polynomial equations. For the 1897 survey of T.23N., R.9W., the total RMS error is 13.21 meters, and the range in residuals is 0.25 to 25.96 meters. For the 1902 survey of T.23N., R.9W., the total RMS error is 14.55 meters, and the range in residuals is 0.87 to 24.60 meters. For the 1906 survey of T.24N., R.8W., the total RMS error is 8.21 meters, and the range in residuals is 1.38 to 13.88 meters. For the 1913 survey of T.24N., R.8W., the total RMS error is 5.75 meters, and the range in residuals is 1.47 to 12.61 meters. For the 1906 survey of T.24N., R.9W., the total RMS error is 13.13 meters, and the range in residuals is 1.06 to 36.24 meters.

The 1897, 1902, and 1913 georeferenced surveys were converted from .jpg format to ESRI grids, so that the projection of UTM, Zone 10, NAD 83, meters could be applied. The two 1906 georeferenced surveys were combined into a mosaic using ERDAS Imagine and saved in Imagine format (.img) with the projection of UTM, Zone 10, NAD 83, meters. The georeferenced individual surveys and mosaic were overlain onto the USGS topographic quadrangles, and the locations of relatively stable features, such as roads, were noted on the georeferenced surveys. In general, there is good agreement between the georeferenced surveys and the USGS quadrangles.

Channel Mapping and Assessment

The channel of the Quinault River on the 1897 and 1906 georefernced surveys was digitized using Arc. The Quinault River channel is shown in the same position on the 1902 and 1913 surveys as it is on the 1897 and 1906 surveys. Consequently, the 1902 and 1913 surveys were not used in our study. The main channel of the Quinault River and tributaries are shown on both the 1897 and 1906 surveys. Sloughs also are shown on the 1897 survey. The tributaries and sloughs were digitized using Arc.

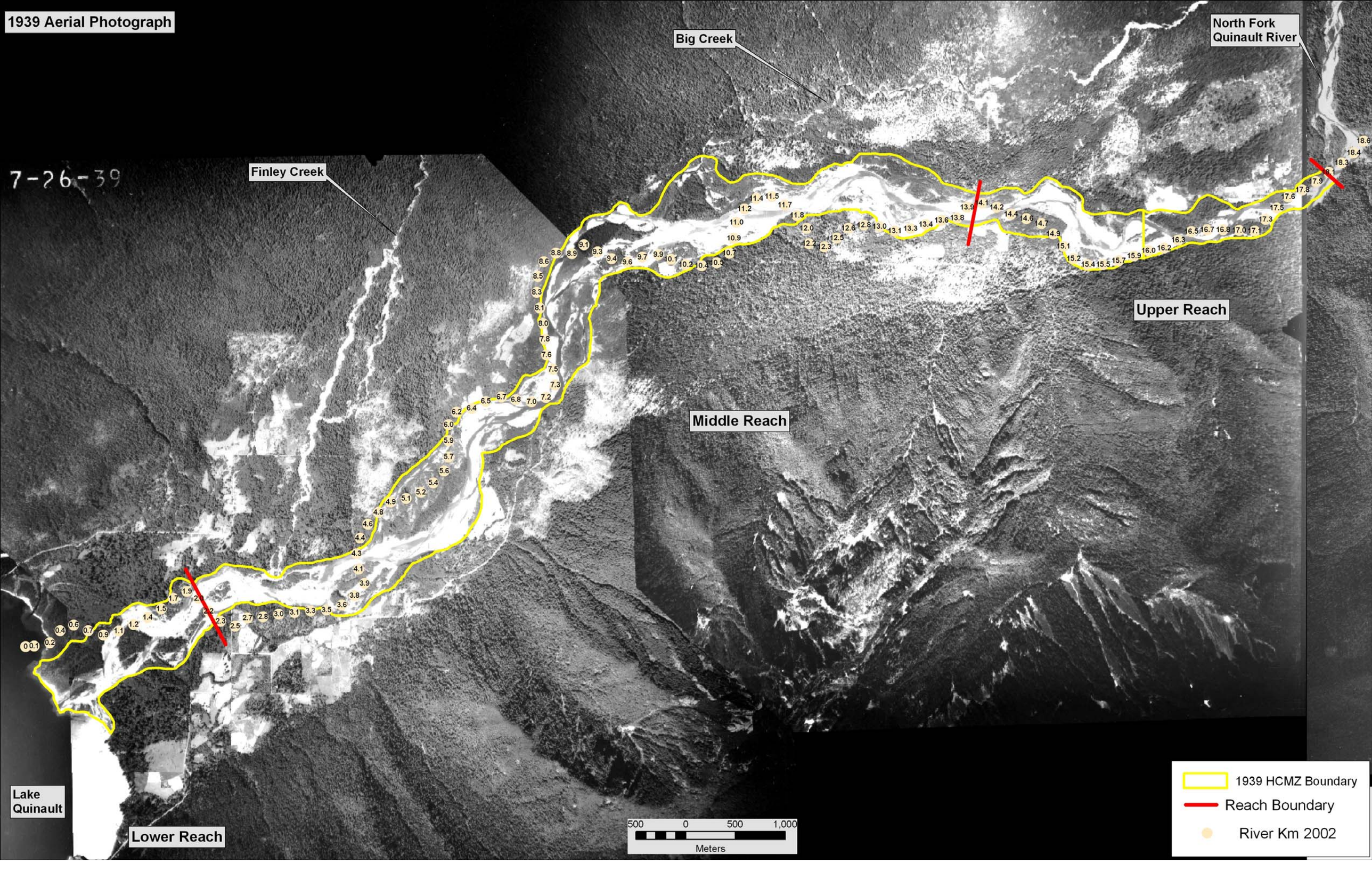
The Quainault River channels shown on the 1897 and 1906 surveys broadly match the configuration of the low-flow and unvegetated channels present on the 1939 aerial photographs and on the USGS topographic quadrangles. The channels on the older maps are almost entirely within the channel zone that is visible on a hillshade constructed from LIDAR data collected in 2002.

In two places, the 1906 channel between the junction with the North Fork and about 2000 meters downstream extends 80 or 100 meters into the steep (rock) slope along the south side of the valley. Along the North Fork, the 1906 channel extends up to 1500 meters into relatively steep topography. The tributaries on both the 1897 and 1906 maps are generally in good agreement with drainages shown on the USGS topographic quadrangles and with channels that are visible on the hillshade (2002). A few tributaries on the south side of the main valley appear to be incorrectly placed (relative to their location on the USGS quadrangles) by about 100 m or less.

The incorrect locations of both the main channel of the Quinault River and some of the tributaries on the south side of the valley on the 1906 map probable occurred because no surveying was done in the steep areas. The south valley wall is a very steep bedrock slope. Locations in the valley appear to be accurate.

Comparison of the 1897 and 1906 channels with the 1939 aerial photograph reveals that the 1897 and 1906 channels, which are probably unvegetated (not low-flow) channels because of their widths, roughly correspond with the channel area in 1939. In the downstream about 5700 meters of our study reach, the 1897 channel is straighter than the unvegetated channel in 1939, but the older channel coincides with the zone created by the unvegetated channel in 1939. Upstream of this area, the 1906 channel is near the 1939 unvegetated channel or in areas where less active (overflow) channels are visible on the 1939 aerial photographs.

Because of the seemingly accurate locations of the 1897 and 1906 channels, we use them in our identification of historical channel paths. The portrayal of the Quinault River channel on the older maps provides verification of the general channel position, as well as human development within the study reach approximately 100 years ago (106 years for the about 5700 meters upstream of Lake Quainault and 97 years for the portion upstream of this to the Forks Bridge). On the 1897 and 1906 surveys, buildings with names, roads, and notes showing cleared areas or orchards indicate the locations of homesteads in the valley at the times of the surveys.


1939 Aerial Photograph
7-26-39
Big Creek
North Fork
Quinault River
Finley Creek
Upper Reach
Middle Reach
Lower Reach
Lake
Quinault
0 0.1 0.2 0.4 0.6 0.7 0.9 1.1 1.2 1.4 1.5 1.7 1.9 2.0 2.2 2.3 2.5 2.7 2.8 3.0 3.1 3.3 3.5 3.6 3.8 3.9 4.1 4.3 4.4 4.6 4.8 4.9 5.1 5.2 5.4 5.6 5.7 5.9 6.0 6.2 6.4 6.5 6.7 6.8 7.0 7.2 7.3 7.5 7.6 7.8 8.0 8.1 8.3 8.5 8.6 8.8 8.9 9.1 9.3 9.4 9.6 9.7 9.9 10.1 10.2 10.4 10.5 10.7 10.9 11.0 11.2 11.4 11.5 11.7 11.8 12.0 12.2 12.3 12.5 12.6 12.8 13.0 13.1 13.3 13.4 13.6 13.8 13.9 14.1 14.2 14.4 14.6 14.7 14.9 15.1 15.2 15.4 15.5 15.7 15.9 16.0 16.2 16.3 16.5 16.7 16.8 17.0 17.1 17.3 17.5 17.6 17.8 17.9 18.1 18.3 18.4 18.6
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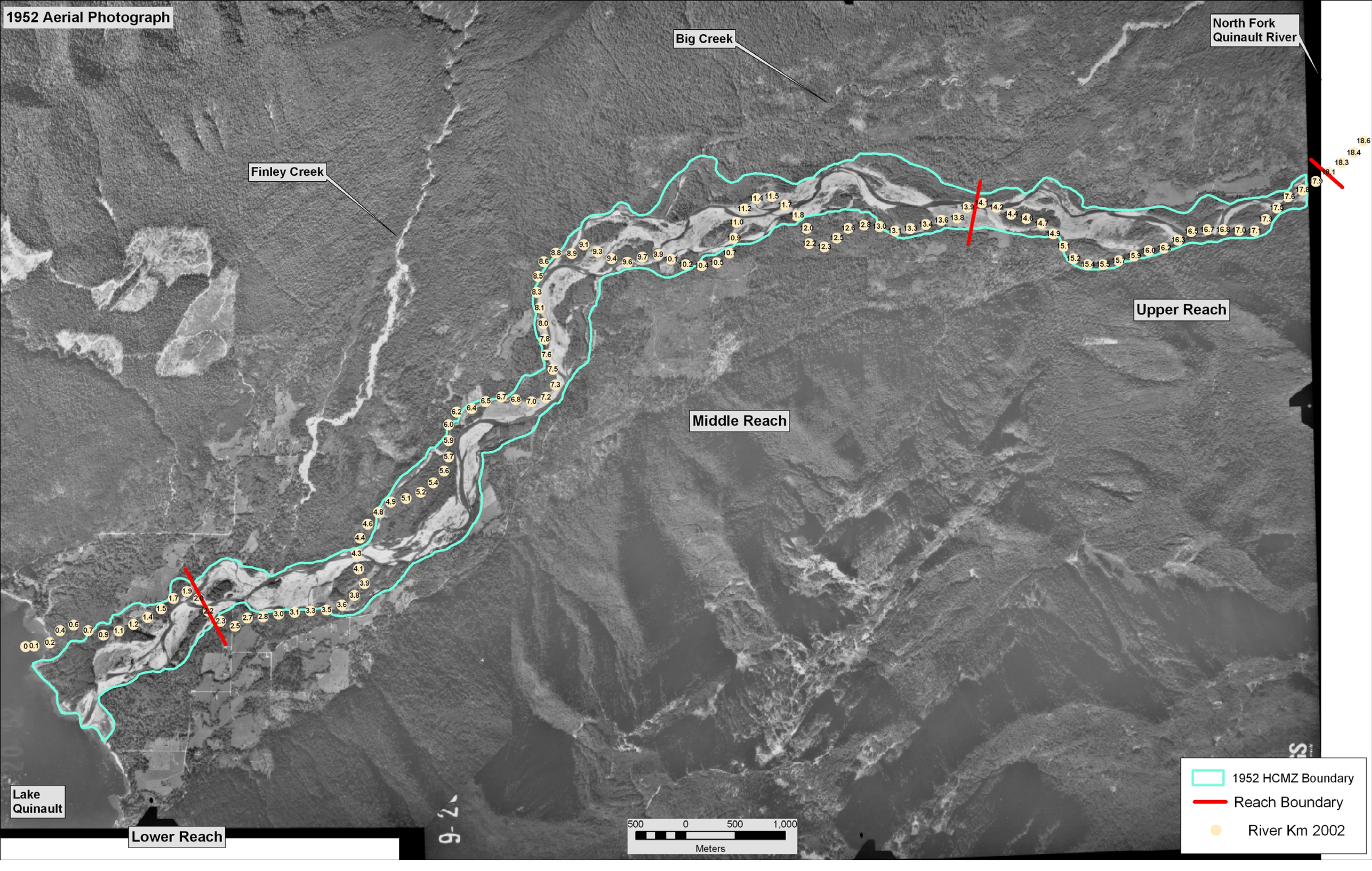
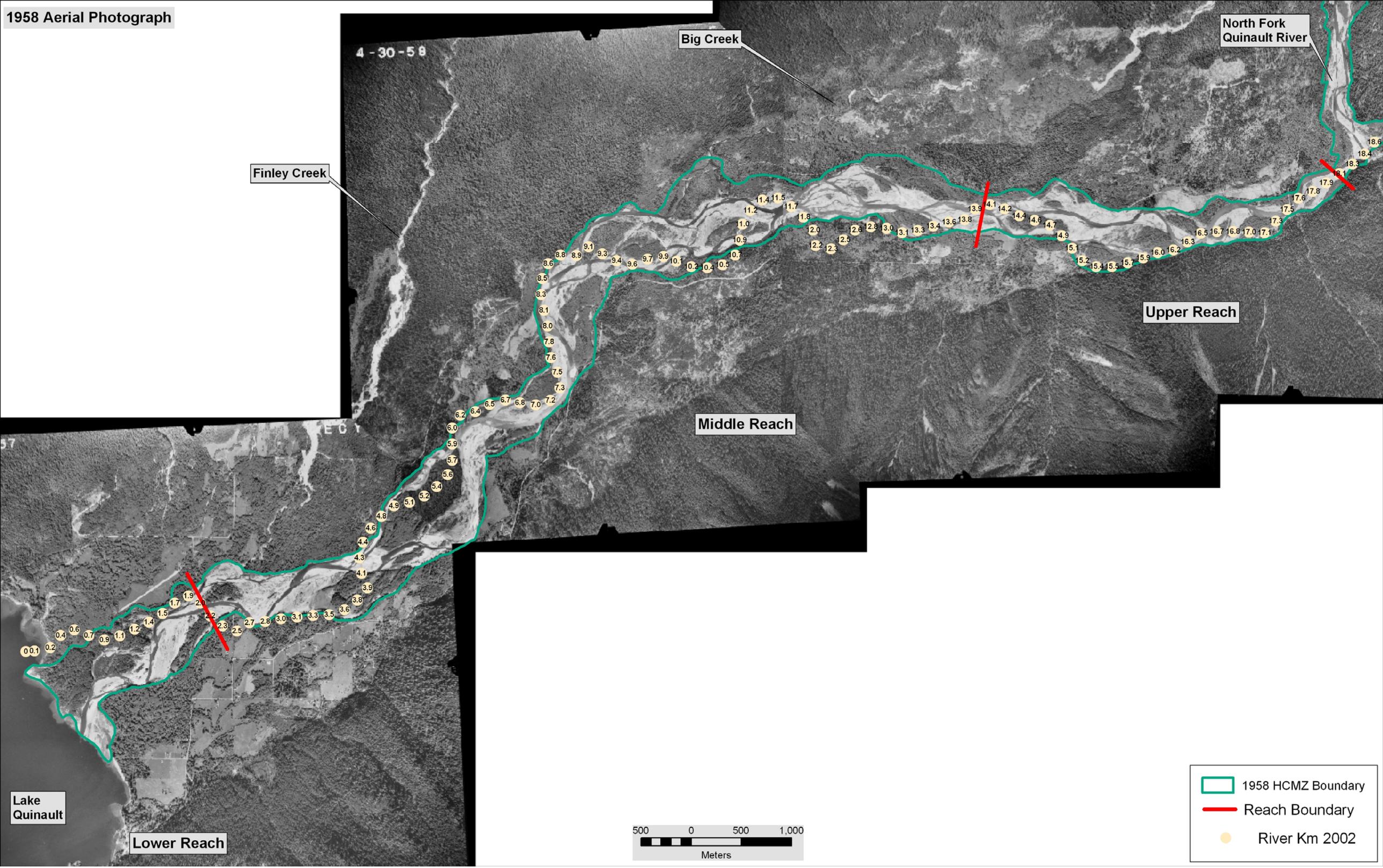
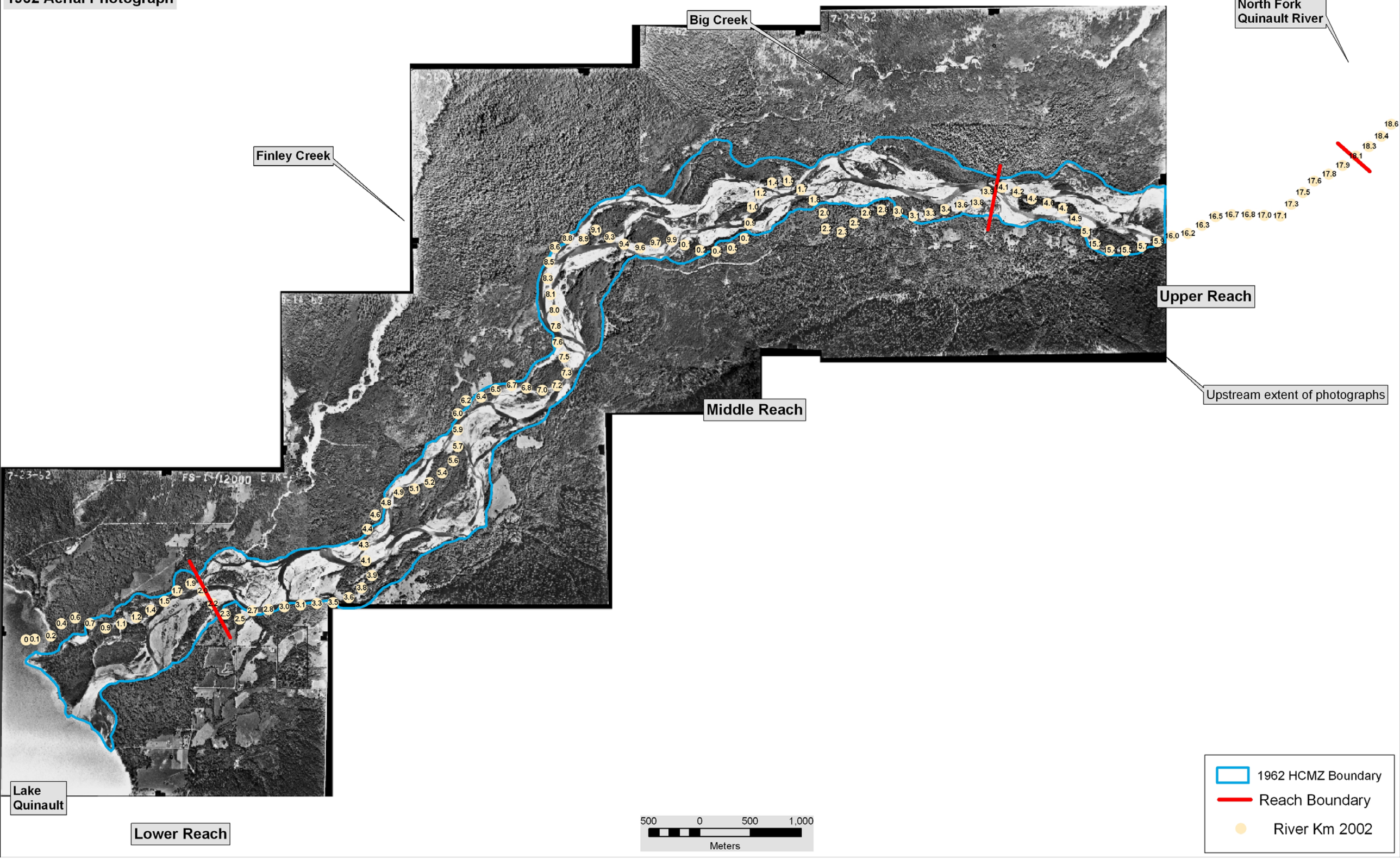
Meters
1939 HCMZ Boundary
Reach Boundary
River Km 2002


1952 Aerial Photograph
Big Creek
North Fork
Quinault River
Finley Creek
Upper Reach
Middle Reach
Lower Reach
Lake
Quinault
0 0.1 0.2 0.4 0.6 0.7 0.9 1.1 1.2 1.4 1.5 1.7 1.9 2.0 2.2 2.3 2.5 2.7 2.8 3.0 3.1 3.3 3.5 3.6 3.8 3.9 4.1 4.3 4.4 4.6 4.8 4.9 5.1 5.2 5.4 5.6 5.7 5.9 6.0 6.2 6.4 6.5 6.7 6.8 7.0 7.2 7.3 7.5 7.6 7.8 8.0 8.1 8.3 8.5 8.6 8.8 8.9 9.1 9.3 9.4 9.6 9.7 9.9 10.1 10.2 10.4 10.5 10.7 10.9 11.0 11.2 11.4 11.5 11.7 11.8 12.0 12.2 12.3 12.5 12.6 12.8 13.0 13.1 13.3 13.4 13.6 13.8 13.9 14.1 14.2 14.4 14.6 14.7 14.9 15.1 15.2 15.4 15.5 15.7 15.9 16.0 16.2 16.3 16.5 16.7 16.8 17.0 17.1 17.3 17.5 17.6 17.8 17.9 18.1 18.3 18.4 18.6
500 0 500 1,000
Meters
1952 HCMZ Boundary
Reach Boundary
River Km 2002


1958 Aerial Photograph
4-30-58
Big Creek
North Fork
Quinault River
Finley Creek
Upper Reach
Middle Reach
Lower Reach
Lake
Quinault
0 0.1 0.2 0.4 0.6 0.7 0.9 1.1 1.2 1.4 1.5 1.7 1.9 2.0 2.2 2.3 2.5 2.7 2.8 3.0 3.1 3.3 3.5 3.6 3.8 3.9 4.1 4.3 4.4 4.6 4.8 4.9 5.1 5.2 5.4 5.6 5.7 5.9 6.0 6.2 6.4 6.5 6.7 6.8 7.0 7.2 7.3 7.5 7.6 7.8 8.0 8.1 8.3 8.5 8.6 8.8 8.9 9.1 9.3 9.4 9.6 9.7 9.9 10.1 10.2 10.4 10.5 10.7 10.9 11.0 11.2 11.4 11.5 11.7 11.8 12.0 12.2 12.3 12.5 12.6 12.8 13.0 13.1 13.3 13.4 13.6 13.8 13.9 14.1 14.2 14.4 14.6 14.7 14.9 15.1 15.2 15.4 15.5 15.7 15.9 16.0 16.2 16.3 16.5 16.7 16.8 17.0 17.1 17.3 17.5 17.6 17.8 17.9 18.1 18.3 18.4 18.6
500 0 500 1,000
Meters
1958 HCMZ Boundary
Reach Boundary
River Km 2002

1962 Aerial Photograph



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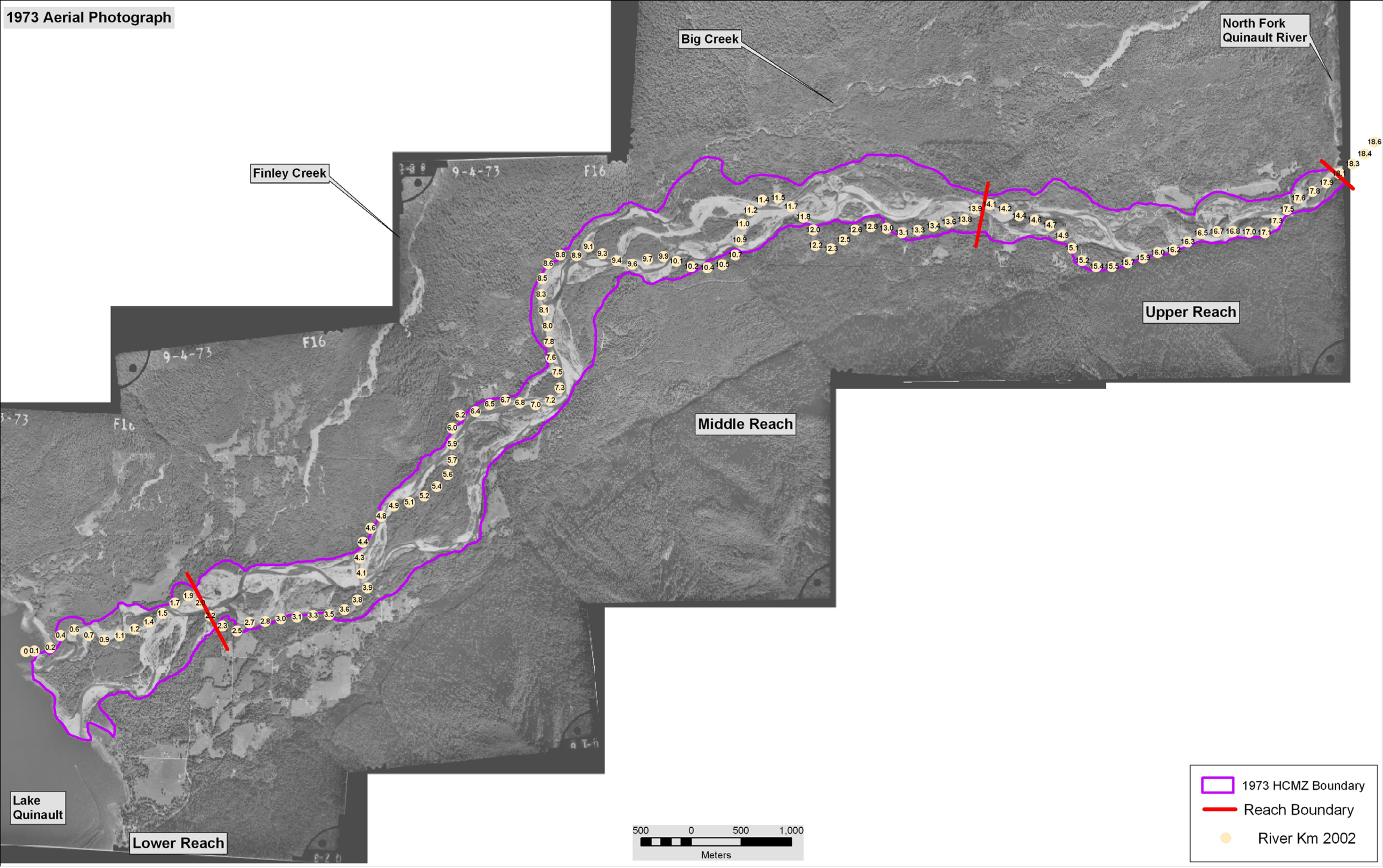
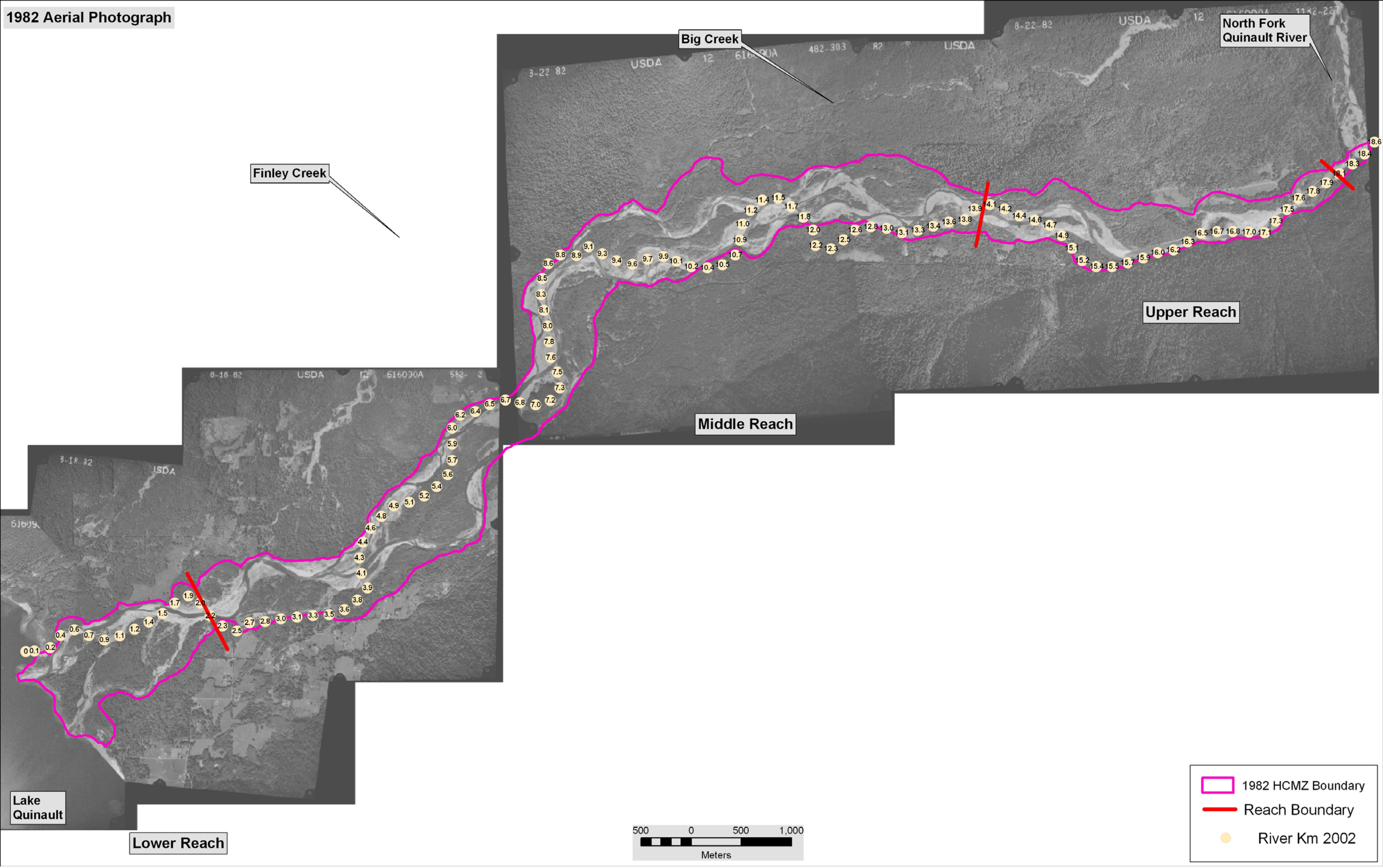
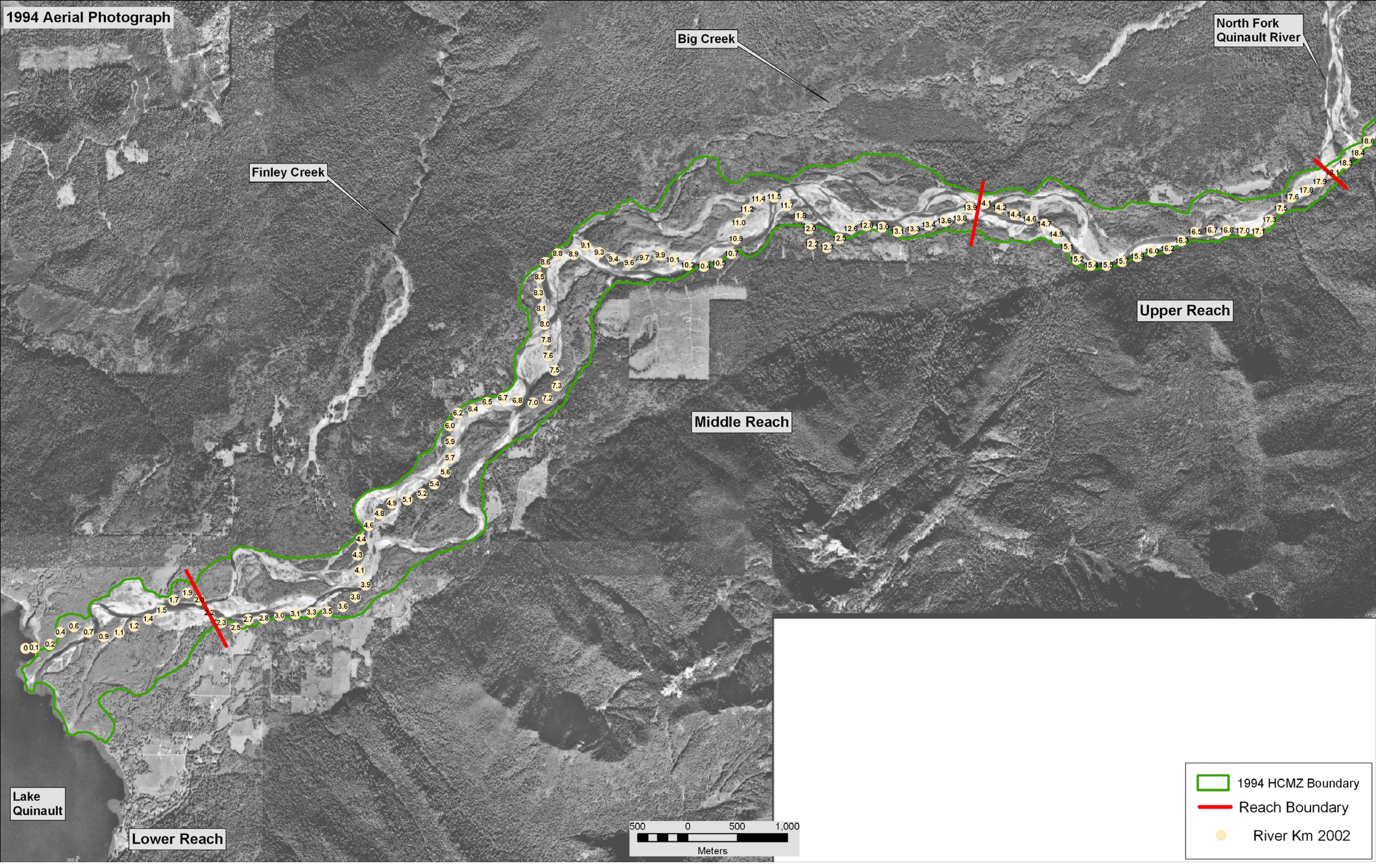
Meters

1962 HCMZ Boundary
Reach Boundary
River Km 2002

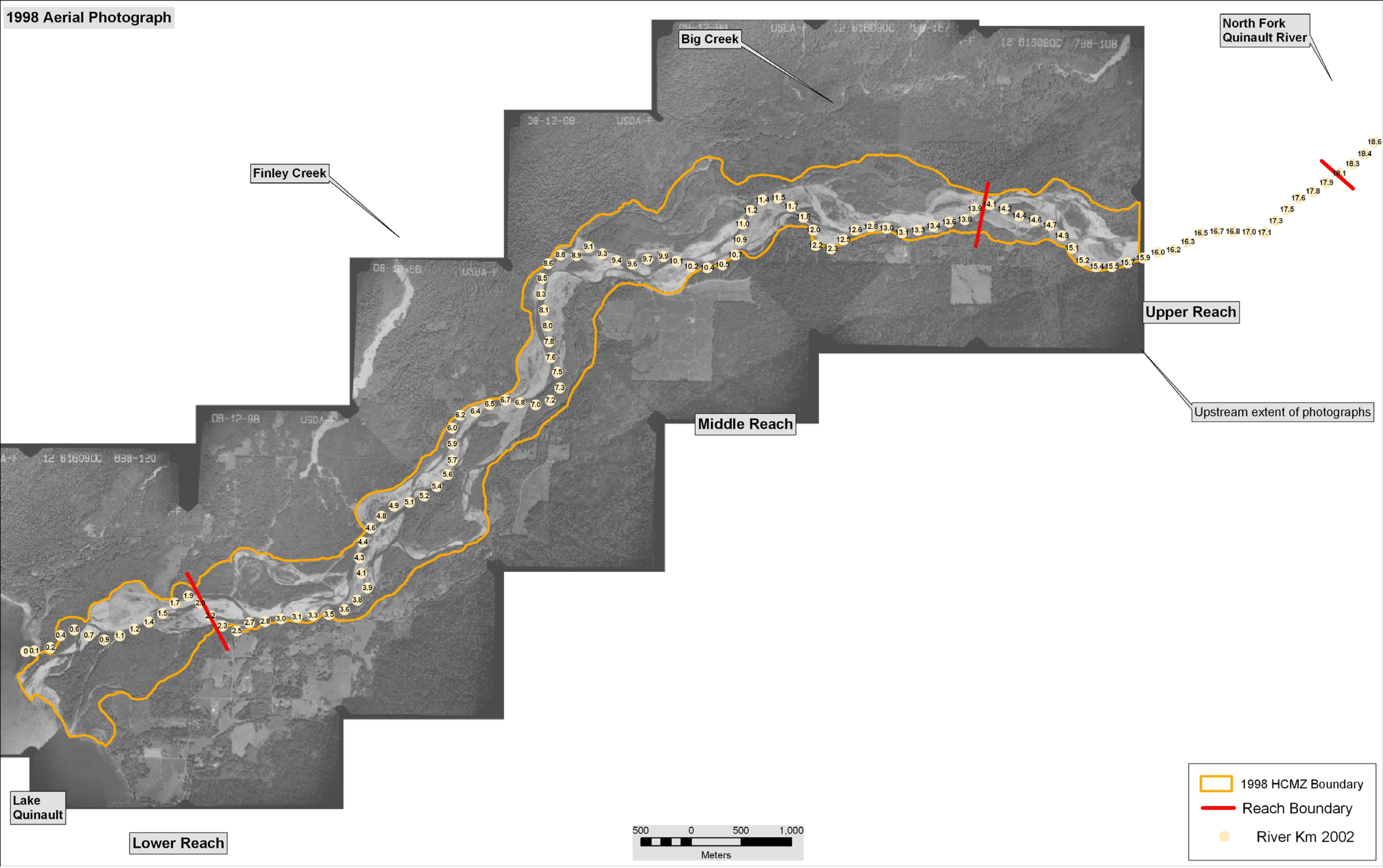

1973 Aerial Photograph
Big Creek
North Fork
Quinault River
Finley Creek
Upper Reach
Middle Reach
Lower Reach
Lake
Quinault
9-4-73
F16
0 0.1 0.2 0.4 0.6 0.7 0.9 1.1 1.2 1.4 1.5 1.7 1.9 2.0 2.2 2.3 2.5 2.7 2.8 3.0 3.1 3.3 3.5 3.6 3.8 3.9 4.1 4.3 4.4 4.6 4.8 4.9 5.1 5.2 5.4 5.6 5.7 6.0 6.2 6.4 6.5 6.7 6.8 7.0 7.2 7.3 7.5 7.6 7.8 8.0 8.1 8.3 8.5 8.6 8.8 8.9 9.1 9.3 9.4 9.6 9.7 9.9 10.1 10.2 10.4 10.5 10.7 10.9 11.0 11.2 11.4 11.5 11.7 11.8 12.0 12.2 12.3 12.5 12.6 12.8 13.0 13.1 13.3 13.4 13.6 13.8 13.9 14.1 14.2 14.4 14.6 14.7 14.9 15.1 15.2 15.4 15.5 15.7 15.9 16.0 16.2 16.3 16.5 16.7 16.8 17.0 17.1 17.3 17.5 17.6 17.8 17.9 18.1 18.3 18.4 18.6
500 0 500 1,000
Meters
1973 HCMZ Boundary
Reach Boundary
River Km 2002

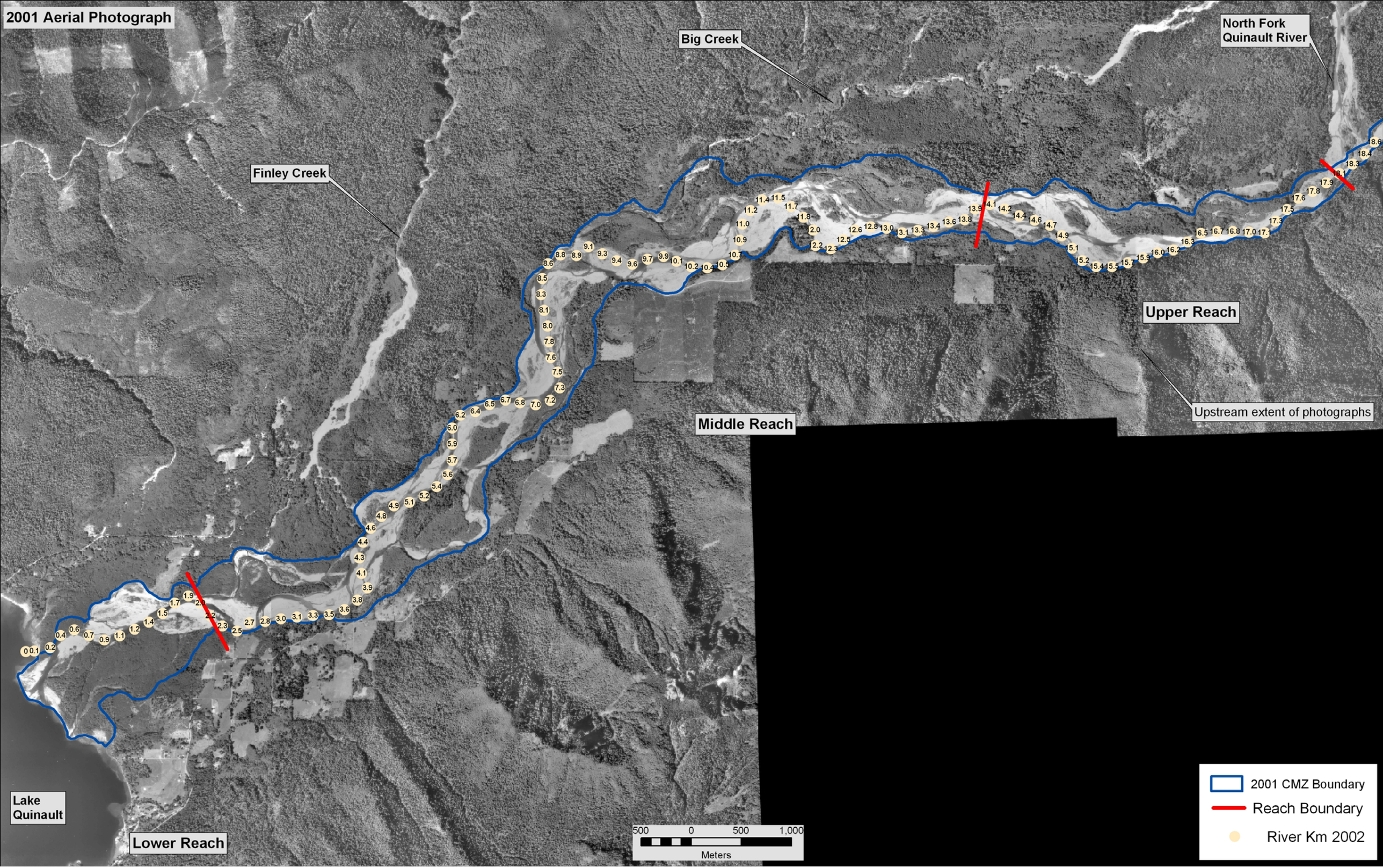
1982 Aerial Photograph

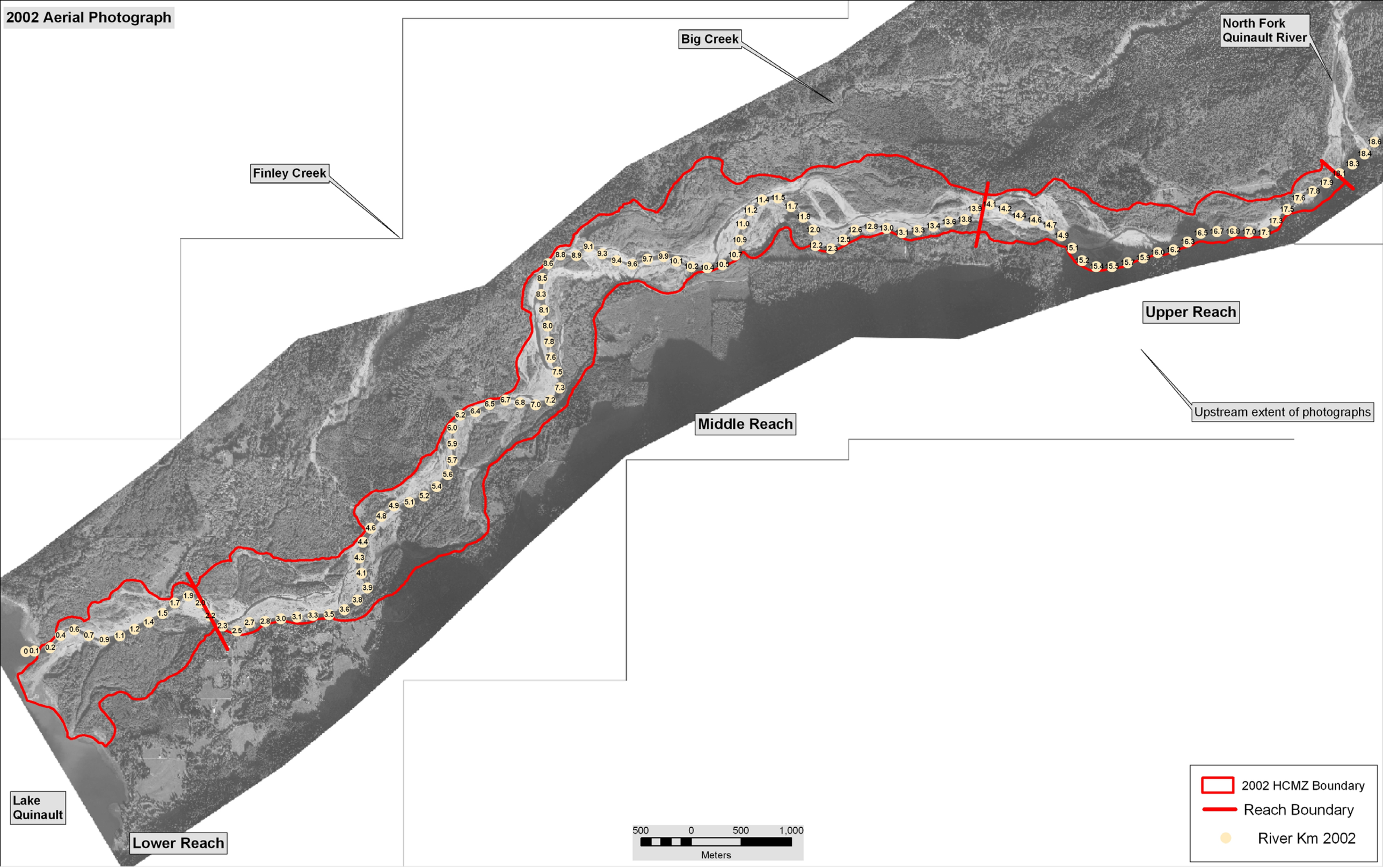



1994 Aerial Photograph
Big Creek
North Fork
Quinault River
Finley Creek
Upper Reach
Middle Reach
Lower Reach
Lake
Quinault
0 0.1 0.2 0.4 0.6 0.7 0.9 1.1 1.2 1.4 1.5 1.7 1.9 2.0 2.2 2.3 2.5 2.7 2.8 3.0 3.1 3.3 3.5 3.6 3.8 3.9 4.1 4.3 4.4 4.6 4.8 4.9 5.1 5.2 5.4 5.6 5.7 5.9 6.0 6.2 6.4 6.5 6.7 6.8 7.0 7.2 7.3 7.5 7.6 7.8 8.0 8.1 8.3 8.5 8.6 8.8 8.9 9.1 9.3 9.4 9.6 9.7 9.9 10.1 10.2 10.4 10.5 10.7 10.9 11.0 11.2 11.4 11.5 11.7 11.8 12.0 12.2 12.3 12.5 12.6 12.8 13.0 13.1 13.3 13.4 13.6 13.8 13.9 14.1 14.2 14.4 14.6 14.7 14.9 15.1 15.2 15.4 15.5 15.7 15.9 16.0 16.2 16.3 16.5 16.7 16.8 17.0 17.1 17.3 17.5 17.6 17.8 17.9 18.1 18.3 18.4 18.6
500 0 500 1,000
Meters
1994 HCMZ Boundary
Reach Boundary
River Km 2002

1998 Aerial Photograph




2001 Aerial Photograph
Big Creek
North Fork
Quinault River
Finley Creek
Upper Reach
Middle Reach
Lower Reach
Upstream extent of photographs
Lake
Quinault
0 0.1 0.2 0.4 0.6 0.7 0.9 1.1 1.2 1.4 1.5 1.7 1.9 2.0 2.2 2.3 2.5 2.7 2.8 3.0 3.1 3.3 3.5 3.6 3.8 3.9 4.1 4.3 4.4 4.6 4.8 4.9 5.1 5.2 5.4 5.6 5.7 5.9 6.0 6.2 6.4 6.5 6.7 6.8 7.0 7.2 7.3 7.5 7.6 7.8 8.0 8.1 8.3 8.5 8.6 8.8 8.9 9.1 9.3 9.4 9.6 9.7 9.9 10.1 10.2 10.4 10.5 10.7 10.9 11.0 11.2 11.4 11.5 11.7 11.8 12.0 12.2 12.3 12.5 12.6 12.8 13.0 13.1 13.3 13.4 13.6 13.8 13.9 14.1 14.2 14.4 14.6 14.7 14.9 15.1 15.2 15.4 15.5 15.7 15.9 16.0 16.2 16.3 16.5 16.7 16.8 17.0 17.1 17.3 17.5 17.6 17.8 17.9 18.1 18.3 18.4 18.6
500 0 500 1,000
Meters
2001 CMZ Boundary
Reach Boundary
River Km 2002


2002 Aerial Photograph
Big Creek
North Fork
Quinault River
Finley Creek
Upper Reach
Middle Reach
Lower Reach
Lake
Quinault
Upstream extent of photographs
0 0.1 0.2 0.4 0.6 0.7 0.9 1.1 1.2 1.4 1.5 1.7 1.9 2.0 2.2 2.3 2.5 2.7 2.8 3.0 3.1 3.3 3.5 3.6 3.8 3.9 4.1 4.3 4.4 4.6 4.8 4.9 5.1 5.2 5.4 5.6 5.7 5.9 6.0 6.2 6.4 6.5 6.7 6.8 7.0 7.2 7.3 7.5 7.6 7.8 8.0 8.1 8.3 8.5 8.6 8.8 8.9 9.1 9.3 9.4 9.6 9.7 9.9 10.1 10.2 10.4 10.5 10.7 10.9 11.0 11.2 11.4 11.5 11.7 11.8 12.0 12.2 12.3 12.5 12.6 12.8 13.0 13.1 13.3 13.4 13.6 13.8 13.9 14.1 14.2 14.4 14.6 14.7 14.9 15.1 15.2 15.4 15.5 15.7 15.9 16.0 16.2 16.3 16.5 16.7 16.8 17.0 17.1 17.3 17.5 17.6 17.8 17.9 18.1 18.3 18.4 18.6
500 0 500 1,000
Meters
2002 HCMZ Boundary
Reach Boundary
River Km 2002